PRS: Physics Reconstruction and Selection
HCAL/JetsMET group

Status of JetsMET

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U. of Maryland
22-Sep-2001

HCAL/JetsMET Group

S.Eno / S.Kunori - Coordinator

http://home.fnal.gov/~sceno/jpg/Default.htm

Dates:

End 2002 DAQ TDR   (end 2001 for HLT section)
End 2004 Physics TDR

Organization:

- HCAL simulation – Sunanda Banerjee (TIFR)
  - CMSIM/OSCAR(Full/Fast)
  - Verify shower model in G4.
- Calibration & Monitoring – Olga Kodolova (MSU)
  - energy scale of jets, MET, tau
  - -> from detector construction/commission to in-situ calibration.
- HCAL in ORCA – Salavat Abdullin (Maryland)
  - readout simulation + …
- Physics objects with HCAL – Sasha Niketenko (CERN/ITEP)
  - jets, MET & tau

Activities
present and near future

past
present
future

Simulation

- Geometry in CMSIM/OSCAR.
- Verify CMSIM/OSCAR.
- Verify hadron shower physics in G4.

Calibration & Monitoring

- Data definition for Calibration Database
- HF (HB/HE) Calibration scenario
- In-situ calibration
  - γ/Z0-jet balancing // M(jj) for W from top
- Improvement of energy scale (+ resolution) [20GeV-TeV]

ORCA code

- Readout simulation / Jet finder / MET code / ntuple maker

HLT (τ jet, jets, MET)

- L1 verification / HLT algorithm and rates / Trigger table

Physics Analysis

- Dijet / Single top / ttH / qqH, H→ $\tau\tau$, WW, invisible / SUSY / …

HLT for τ-jets /Jets / MET

$\tau^+ \rightarrow \pi^+ \nu$	12.5%
$\tau^+ \rightarrow \rho^+ \nu \rightarrow \pi^+ \pi^0 \nu$	26%
$\tau^+ \rightarrow a_1 \nu \rightarrow \pi^+ \pi^0 \pi^0 \nu$	7.5%

τ-jets

Narrow jet (similar to electron)

BG: QCD jets

→ Refine narrowness — L2: ECAL full segmentation

→ Identify 1/3 charged tracks — L3: Pixel

Jets

BG: QCD jets

Fake (+ additional) jets due to pile-up (E_T<50GeV)

→ Improve energy scale and resolution

→ Remove fakes

MET

BG: badly measured QCD jets (+ hot/dead cell)

b/c semi-leptonic decays (?)

→ Improve energy scale and resolution

→ remove BG's.

τ jets

tau jet:

narrow (one prong) jet

L1/L2:

use only calorimeter

L1: 0.087x0.087

L2: individual crystal

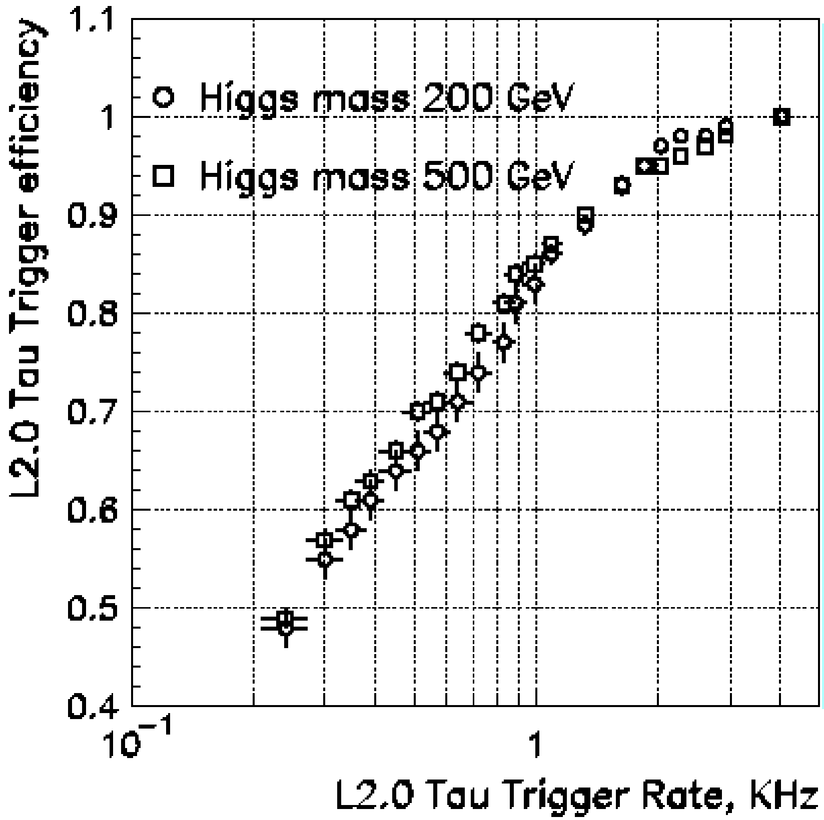
L2.0 Tau trigger

1. reconstruct a Jet*
2. calculate e.m. isolation :

   $P_{isol} = E_t^{ecal}(R < 0.4) - E_t^{ecal}(R < 0.13)$

3. accept event if $P_{isol} < P_{cut}$

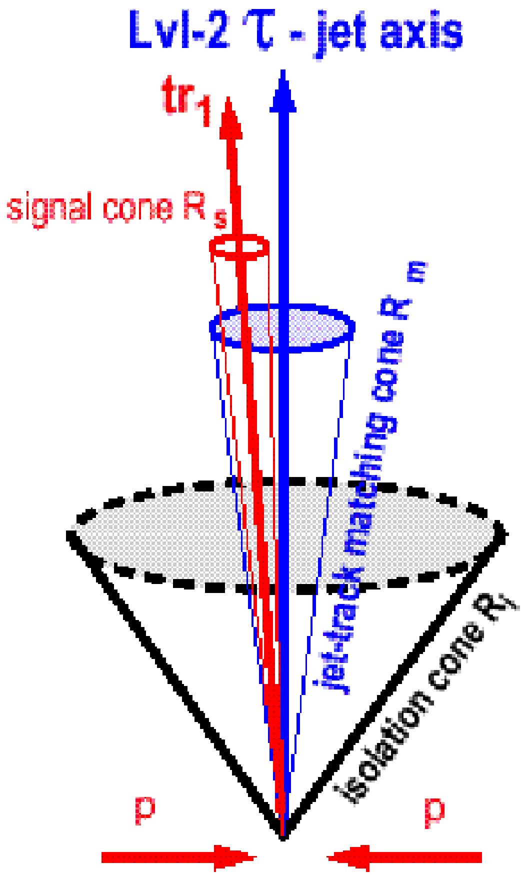
gg->bbA, A->2τ->h⁺ + h⁻ + X

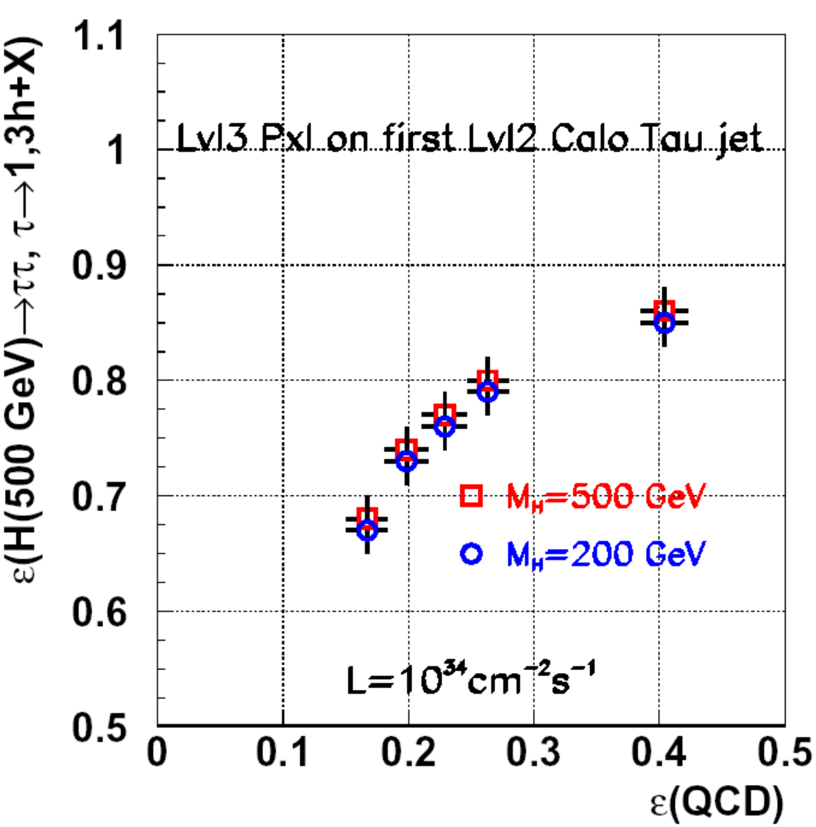


(CMS Note 2000/055)

tau jets at L3

1. Reconstruct track with pixel. (PT>1GeV)
2. Reconstruct primary vertex.
3. Track match (highest PT) to L2 tau jet
4. Track isolation





(CMS Note 2001/017)

HLT Jets and Energy Corrections

Two steps for HLT jets

1) Find jets with R=0.5 –1.0 with fixed calorimeter weights.
2) Correct energy scale to sharpen turn on curve.

Energy Correction

- **Jet based**
  1) E = a x (EC+HC), a depends on jet(ET,η)
  2) E = a x EC + b x HC, a, b depend on jet(ET,η)
- **Particle based**
  1) E = em + had (requires to separate em/had clusters) (#)
     em = a x EC for e/γ
     had = b x EC + c x HC, for had. b (c) depend on EC (HC)
- **Use of reconstructed tracks**
  1) E = E_0 + (Tracks swept away by 4T field) (#)
  2) E = EC(e/γ+neutral) + HC(neutral) + Tracks (#)

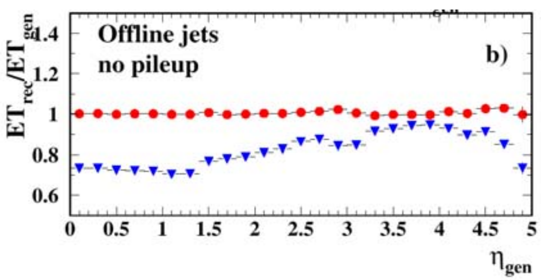
(#) Reports during the cms week.

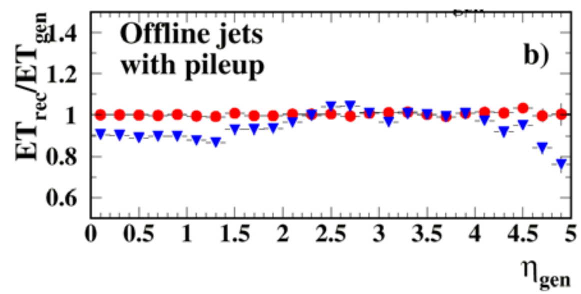
Jet Response and Correction #1

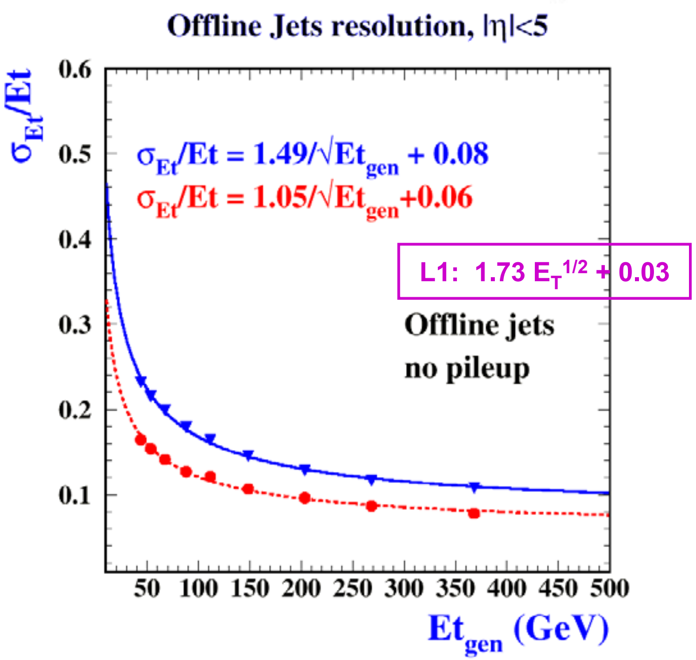
Et-eta dependent correction for QCD jets

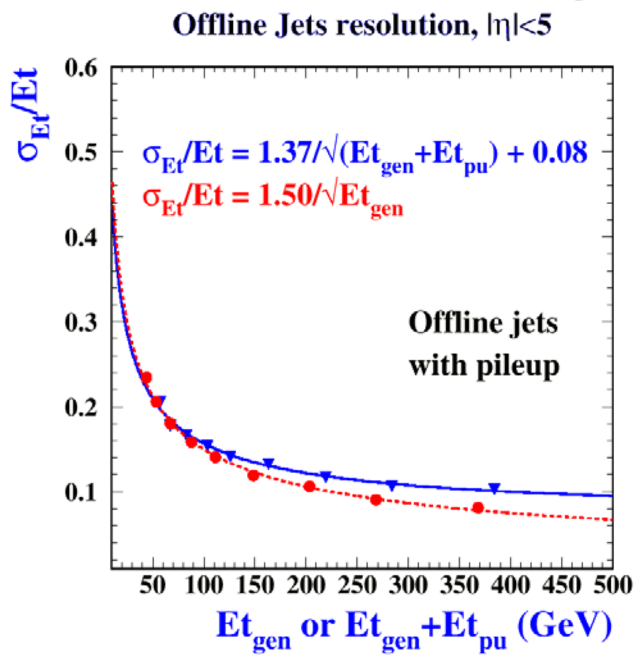
$Et(corr) = a + b \times E_T(rec) + c \times E_T(rec)^2$

No pileup | **With pileup**









Dijet Mass Resolution

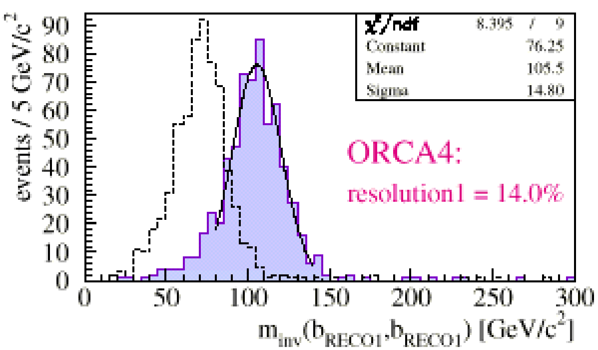
No pileup

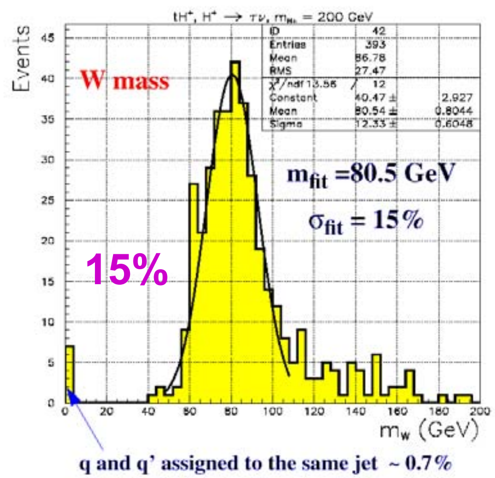
With pileup

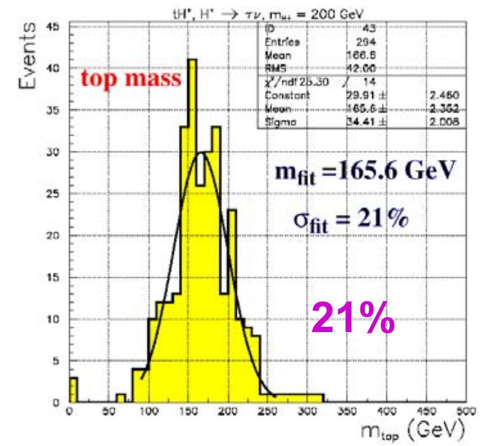
W(jj) **Top(jjj)**

Before correction

M(bb) in WH







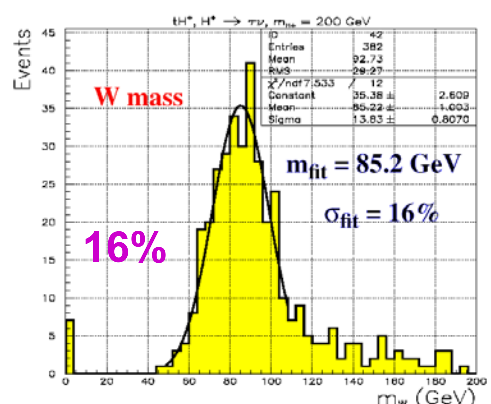
After correction

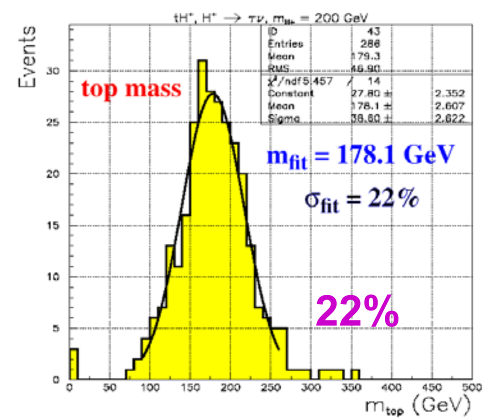
Jet energy correction

without: 19%

with: 14%

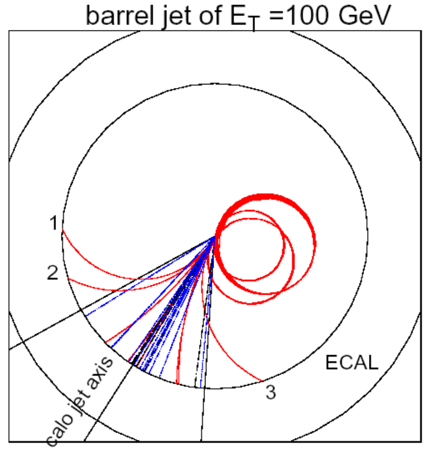
CMSJET 15%



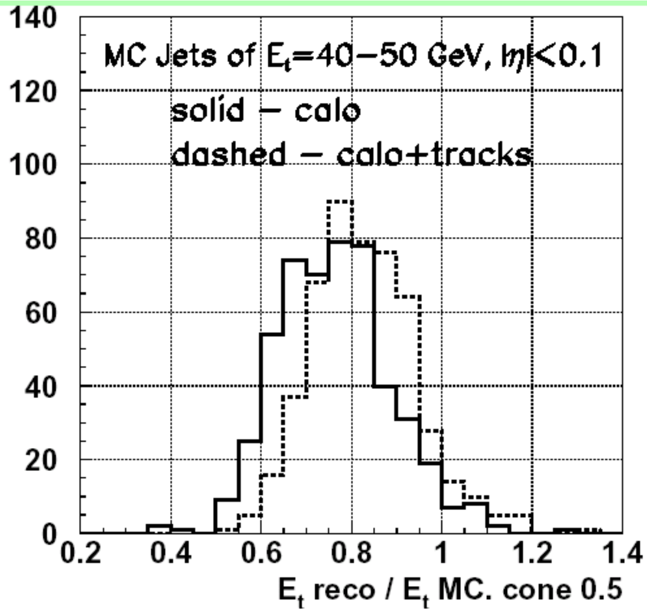


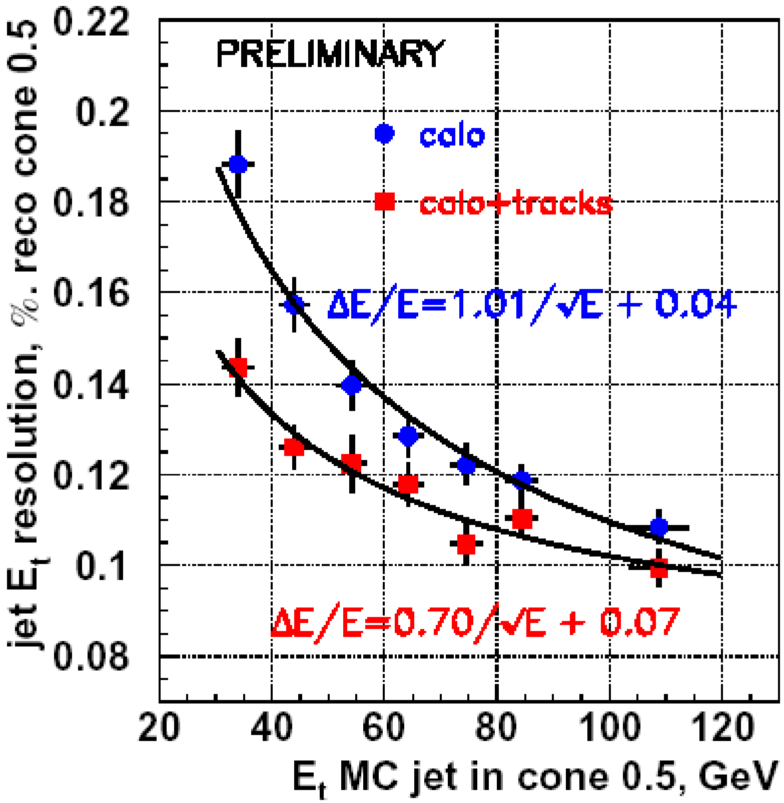
(V.Drollinger) (R.Kinunnen)

$$E_{T\ jet} = E_{T\ jet}^{calo} + p_T^{trks},$$

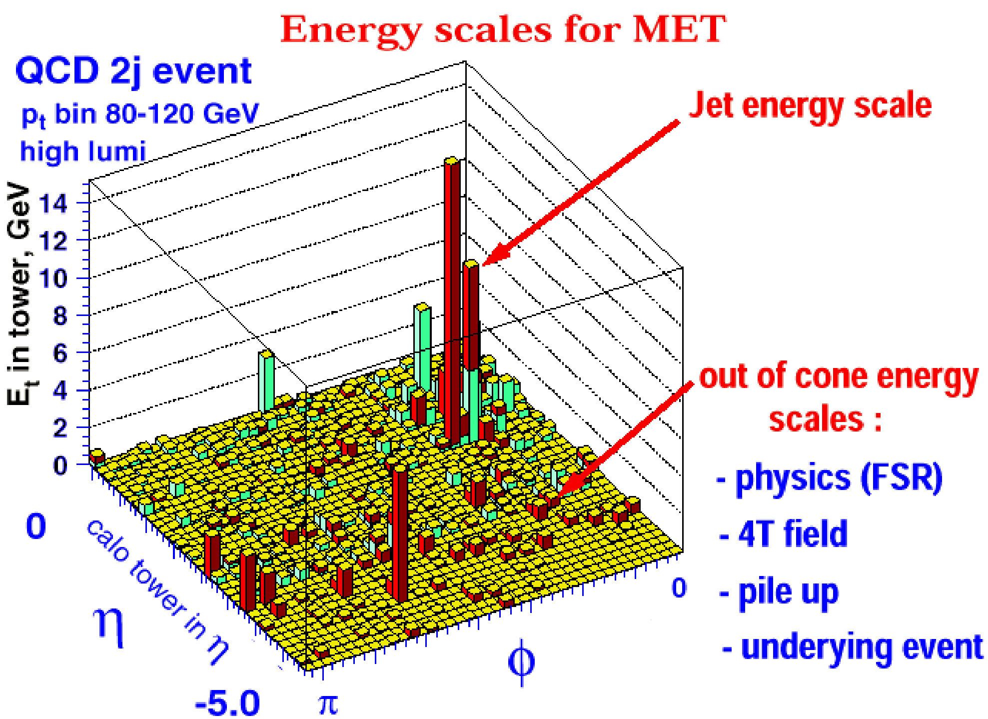


A.Nikitenko
(Talk on Wednesday)

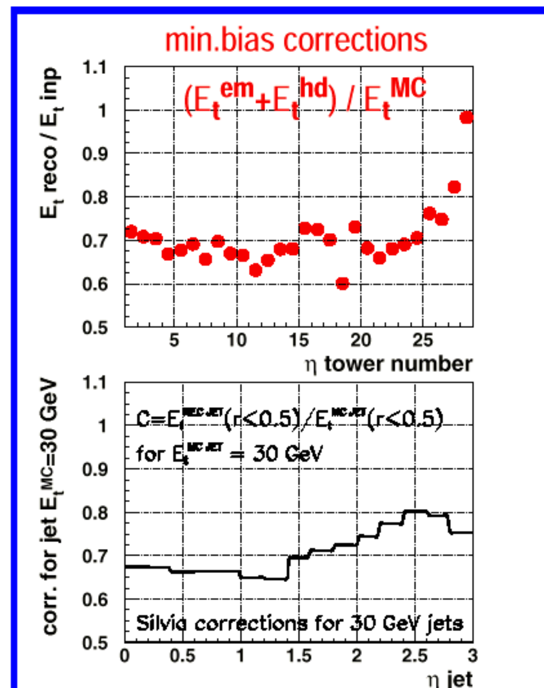




MET



Out of cone corr. uses weights for jet(30GeV) corr.



Corrections

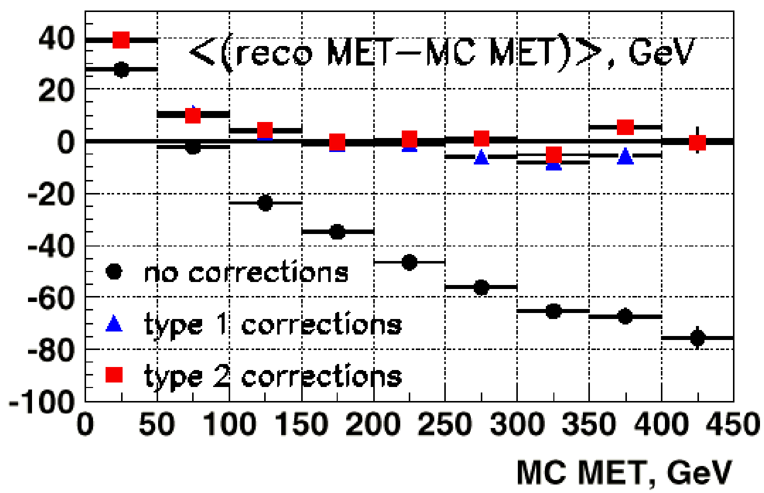
Type 1: Jet corr.

Type 2: Jet corr. + out of cone corr.

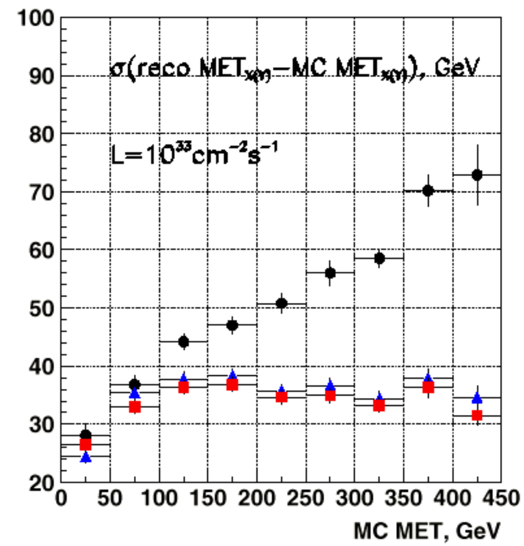
(Nikitenko)

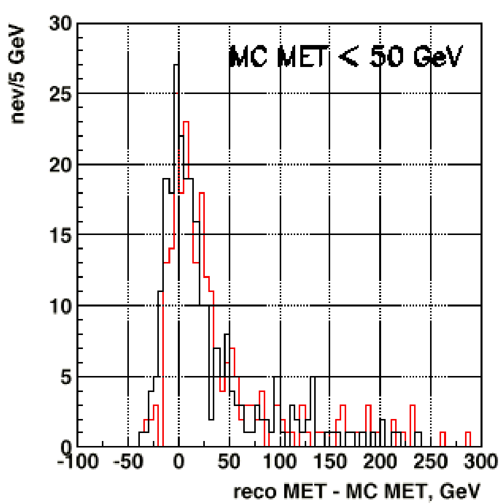
Corrected MET for mSUGURA Jets+MET at low lumi

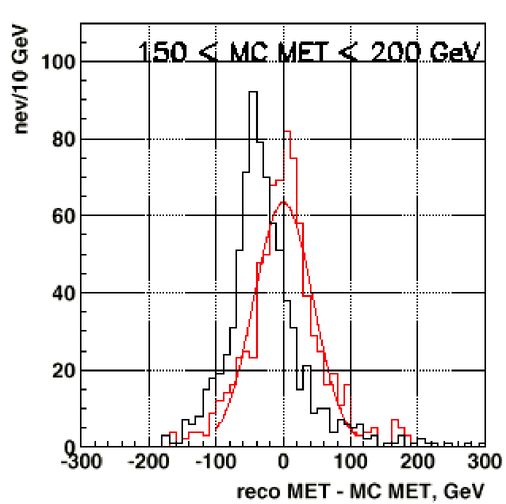
Mean offset

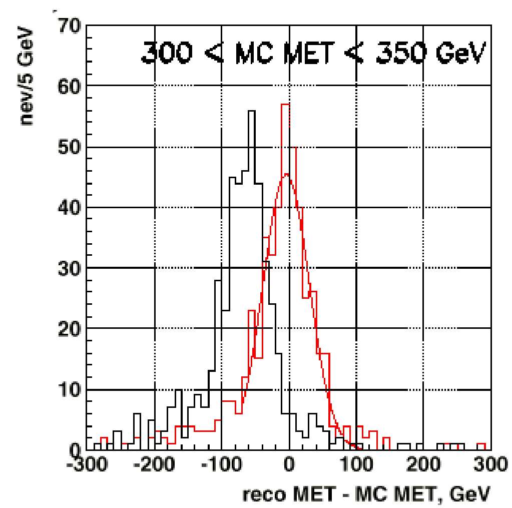


σ





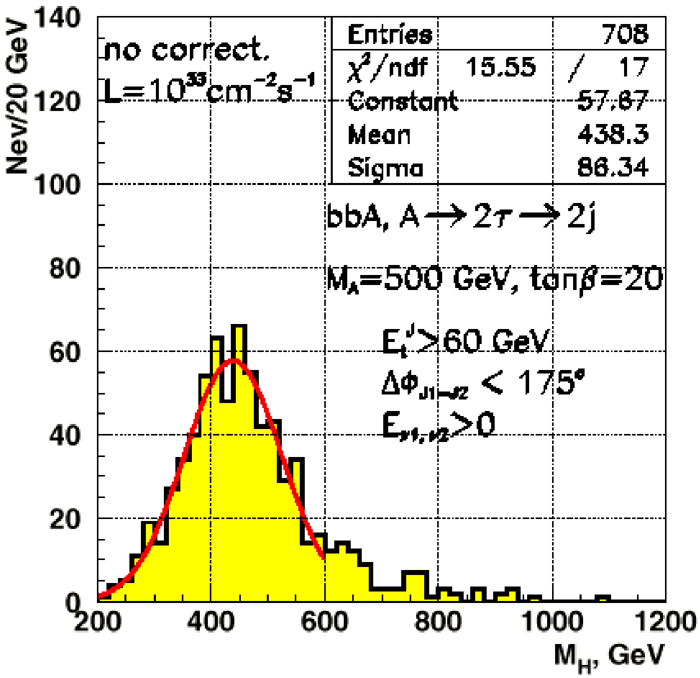




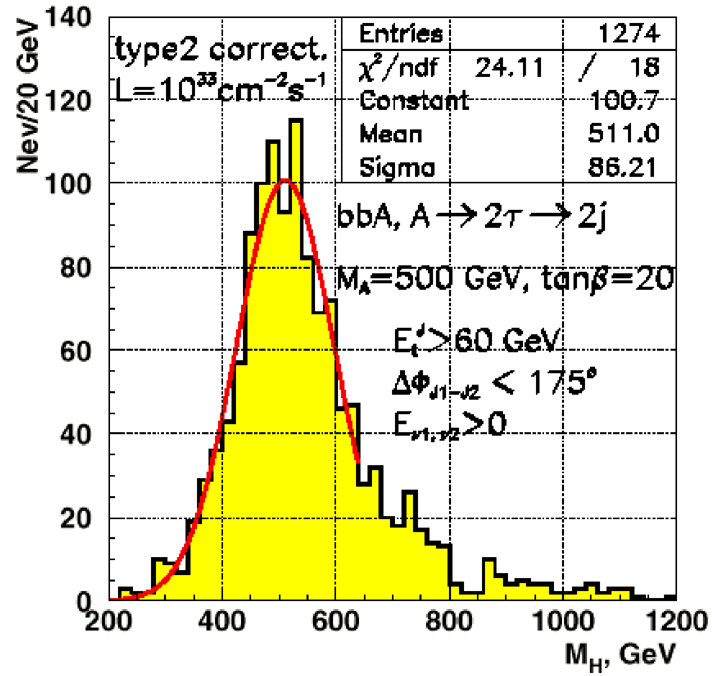
Higgs mass in bbA, A→2τ→2j

(A.Nikitenko)

before correction



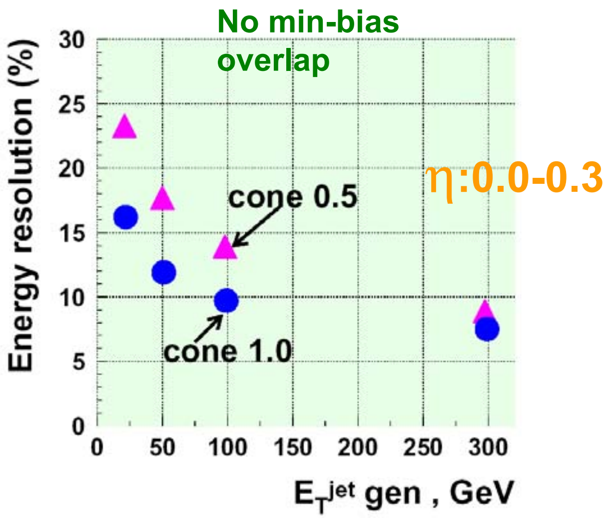
after correction

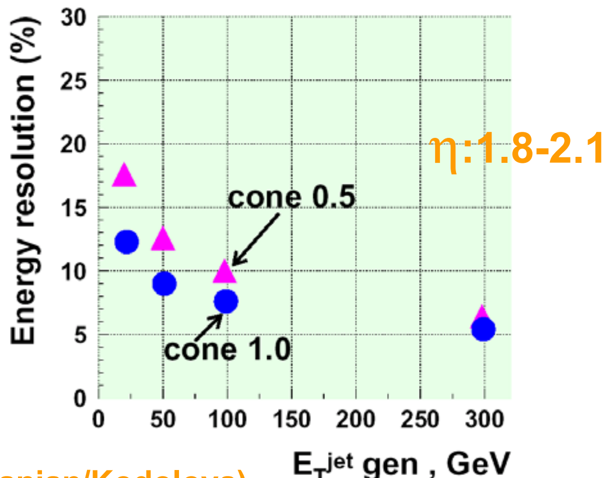


bbA, A->2τ->2j	no corrections	type1 corrections	type2 corrections	CMSJET
$\langle M_H \rangle$	438.3 GeV	500.3 GeV	511.0 GeV	500.0 GeV
$\sigma / \langle M_H \rangle$	19.7 %	18.9 %	16.8 %	13.4 %
ε_{reco} (corr.) / (no corr)	1	1.53	1.80	

Jet Cone Size

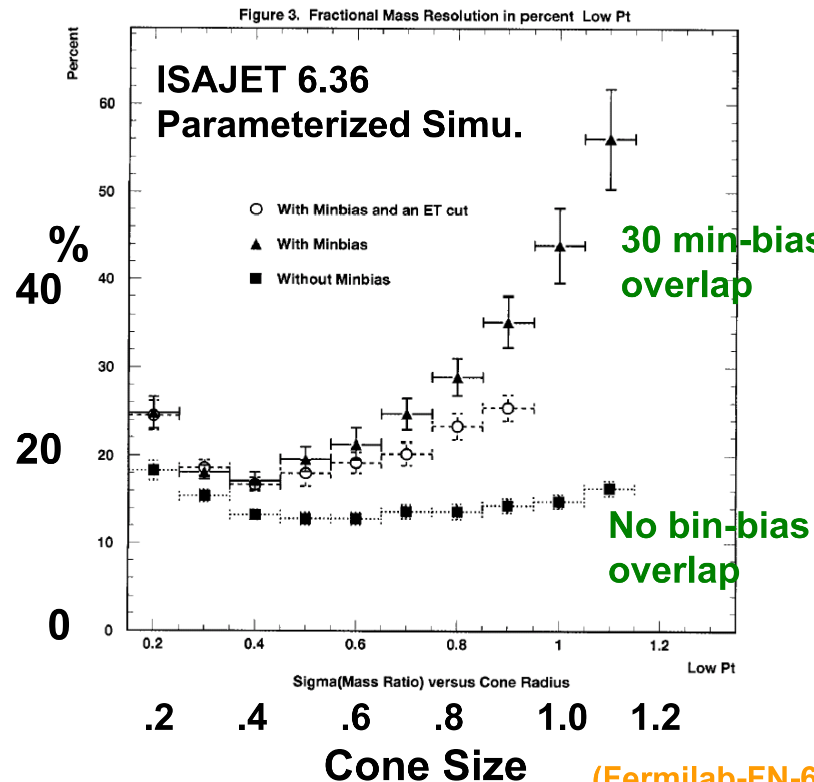
particle-jets vs. reco-jets





(Vardanian/Kodolova)

Resolution of Mass(Z→jj)
- 1994 study -



(Fermilab-FN-626)

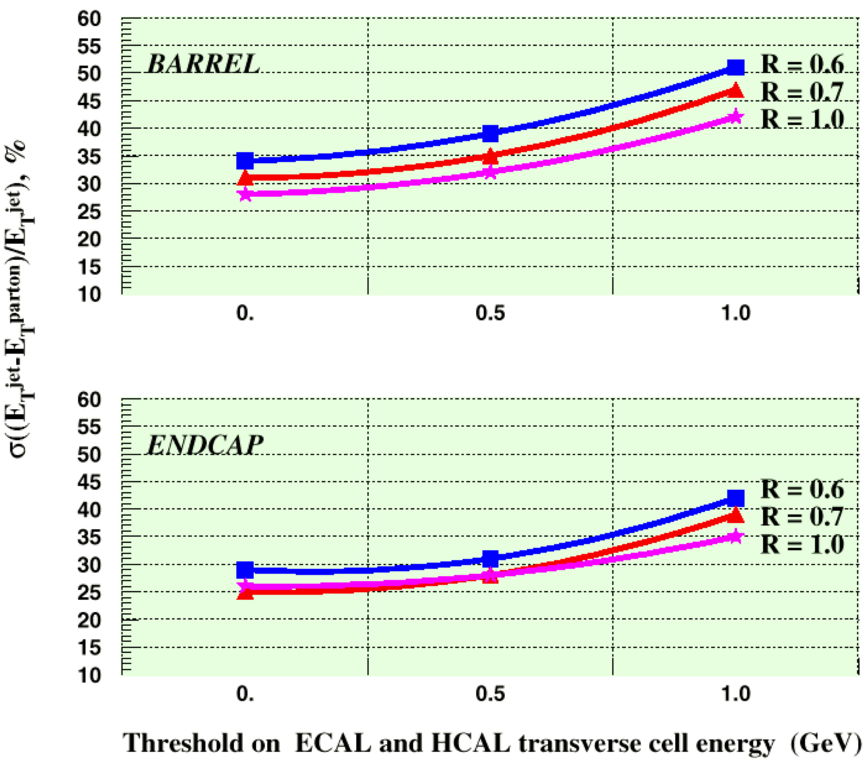
Larger R is better for di-jets @ low luminosity.

→ Need to test with multi jets.

→ @ high luminosity

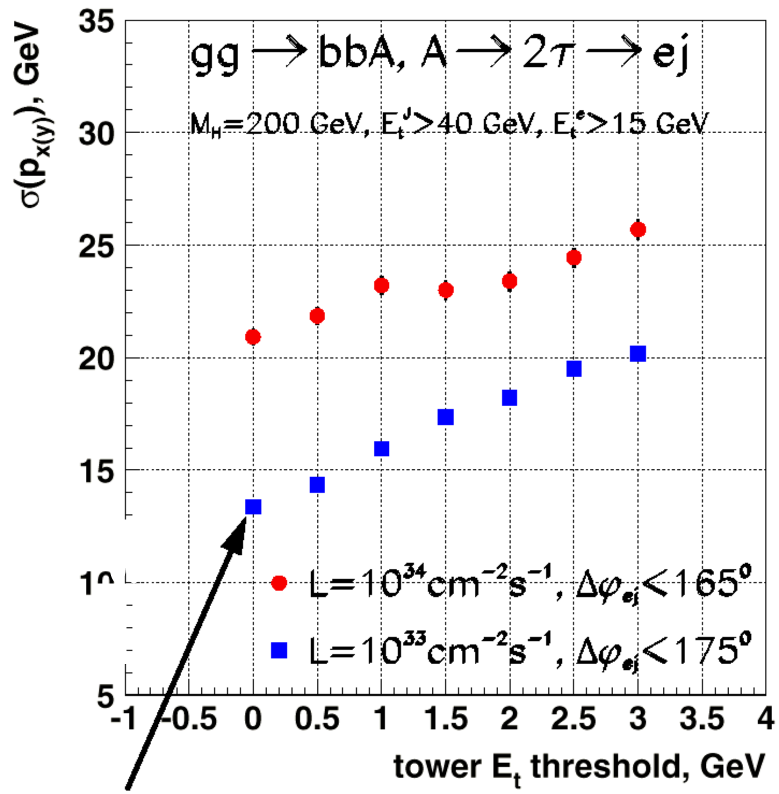
Effect of Threshold on low E_T jet and MET

20GeV parton jet @ 10E34



(I.Vardanian)

MET



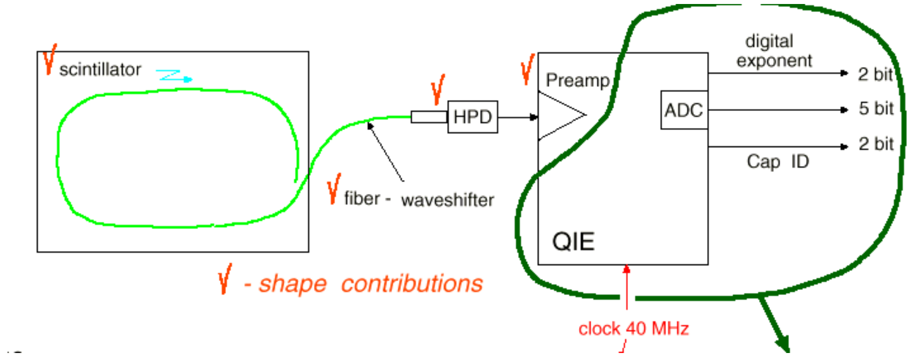
(S.Nikitenko)

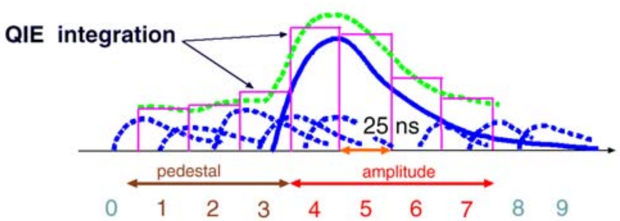
Lower threshold is better!

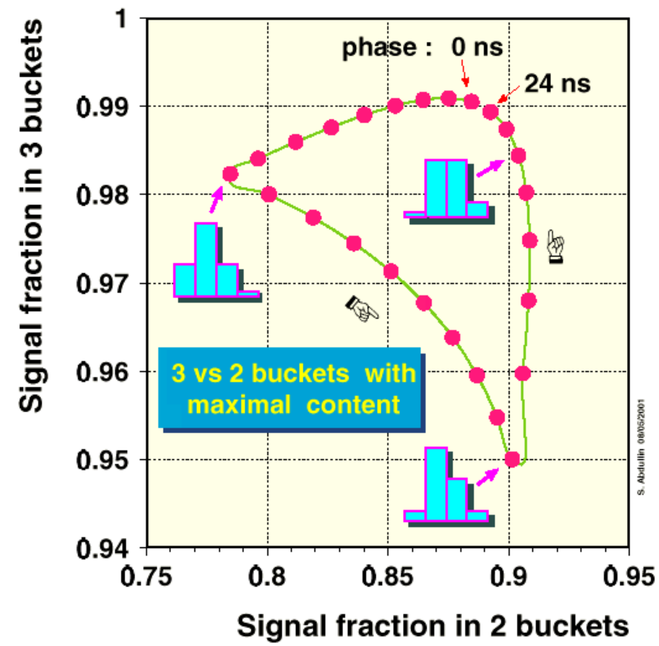
Electronics noise and occupancy define the threshold.
>> aim at 0.5GeV/tower @ 10E34

Front end electronics simulation

(S.Abdoullin)







(Original scheme)

E = Σ (Signal buckets)$_i$ – Σ(pre buckets)$_j$/n

Electronics noise 200MeV/25nsec/ch → 500MeV/(3+3) buckets/ch

→ New scheme: 2 buckets for signal
separate pedestal events

What's next?

Production

- **Complete CMS120 production**
  - Fall 2000 production for 2x10E33
    - **ooDigi – done // Ntuple – done this week, hopefully.**
  - Spring production for 2x10E33
    - **In progress.**
  - Production for 10E34 with new front end elec. simu.
- **Prepare for next production**

HLT rates calculation / Trigger table.

More Improvement …

- **Jets / MET**
  - Algorithm for better resolution and energy scale.
- **MET**
  - Algorithm to remove badly measured jet events.

→ Algorithm for 10E34!

Expanding group

We try to attract more people in the HCAL community and help them to get familiar with the CMS detector, CMS software and physics (analysis) at the LHC.

Assumption:

- geographical spread and diversity in skill level continue.

Strategy:

- lower the threshold for entering software development and data analysis.
- build a core software team for strong support (preferably in US).
- recruit experienced people to coordinate larger number of people.

Potential manpower:

- Universities in US, RDMS (not only ITEP and MSU), India, Turkey, Hungary…
- US CMS Software and Computing Project (Tier1 & CAS)

→ Started distributing hard disks with full CMS SW and MC events.
→ Regional meetings (Moscow, India, US)

Summary

Simulation

- Verify Simulation
- Transition to OSCAR/GEANT4

Calibration & Monitoring

- Scenario from construction to in-situ calibration.
- Improvement for energy scale and resolution.

HCAL Code in ORCA

- Readout simulation

HLT

- CMS120 data finally ready
  → rate calculation and trigger table (2xE33)
- Apply improved algorithm.
- Algorithm for E34.

Additional Slides

Algorithm for L1 through Offline (1)

L1 – calorimeter only (coarse segmentation)

- **Resolution improvement**
  - Equalize calorimeter response with simple correction
    - **a x EC + b x HC,   a,b depends on jet(ET,h)**
    - **a x (EC+HC),   a depends on jet(ET,h)**
- **Fake Jets/Pileup jets rejection**
  - Threshold cut on a central tower in jets (seed cut)

L2 – calorimeter only (fine segmentation)

- **Resolution improvement**
  - Better energy extraction from ADC counts
  - Em/had cluster separation using transverse shower shape in crystals
- **Fake jet/Pileup jet rejection**
  - Use of transverse shower shape

Algorithm for L1 through Offline (2)

L3 – calorimeter plus pixel

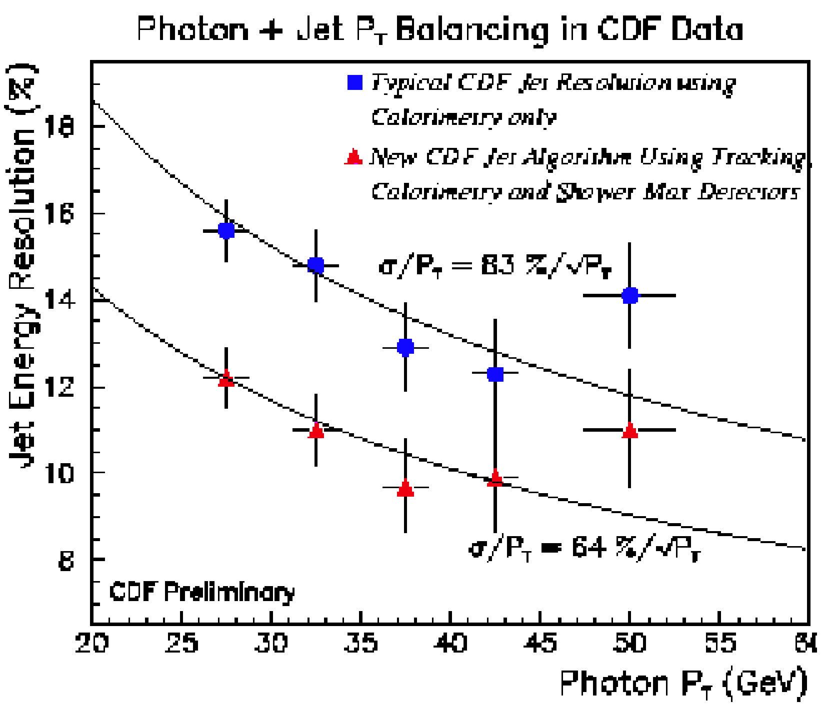
- **Resolution improvement**
  - Pileup energy subtraction
    - **Estimation of energy flow from pileup events using pixel hits/tracks.**
- **Fake jets/Pileup jets rejection**
    - **Vertex information and jet pointing using pixel hits/tracks.**

Offline – calorimeter plus fully reco-ed tracks

- **Resolution improvement**
- **Fake jets/Pileup jets rejection**
  - → Jet and MET will be reconstructed with Tracks, EM clusters and HAD clusters.
  - → All tracks down to E_T~ 700MeV have to be reconstructed at 10E34!
- **Physics correction – e.g. correction for IFR/FSR.**
  - → In-situ calibration!

Improvement of jet energy resolution with tracks

CDF



L3